Quantifying Pumice Content in Soil Mixtures

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Pumiceous Soils

- Soils containing pumiceous materials are known to exist across significant areas of the North Island and are the result of volcanic eruptions in the Taupo Volcanic Zone. These soils are encountered in both their original air-fall deposits, or as alluvially derived soils.
- Pumice grains are vesicular and as a result are lightweight and highly crushable (Figure 1).

Figure 1: Different sized grains of pumice (Stringer, 2019)

- Crushability of pumice grains changes the penetration mechanisms (and therefore the interpretation) of conventional CPTs
  - Existing correlations derived for hard-grained materials might not be suitable in pumice-rich soils. (i.e. Figure 2).
- Asadi et al. 2018 have shown that the liquefaction resistance of pumice rich soils tends to be significantly higher than conventional soils despite their high crushability (Figure 3).

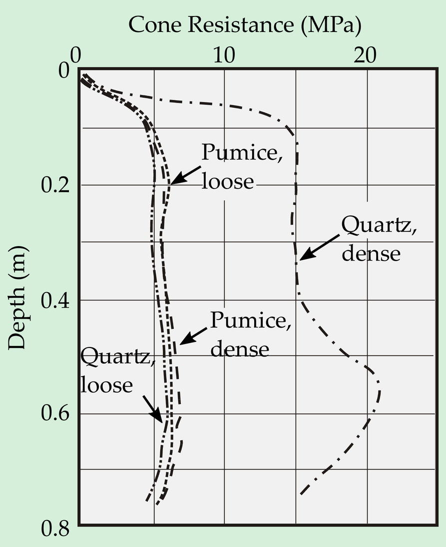

Figure 2: Calibration chamber tests on pumice (Wesley, 1999)

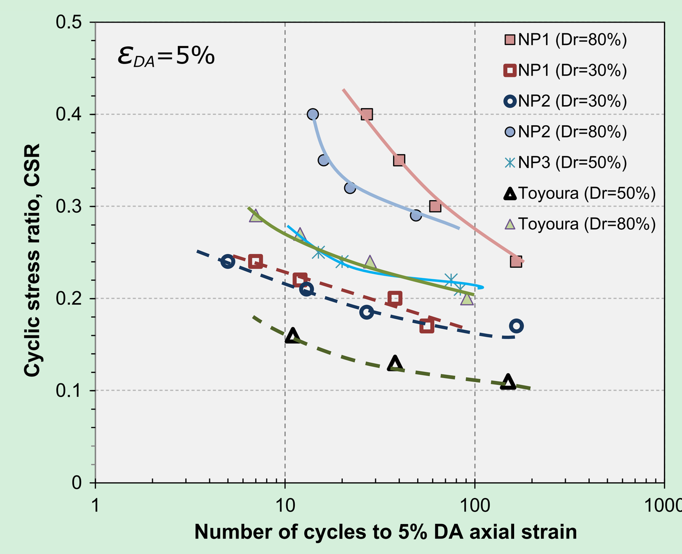

Figure 3: Cyclic resistance of reconstituted specimens (after Asadi et al. 2018)

- The insensitivity to relative density implies that using simplified methods for liquefaction triggering based on the CPT is likely to significantly under-estimate the liquefaction resistance of a soil.
  - Are designs being too over-conservative?
  - How should we account for this with natural soils?

To understand the behaviours of pumice-rich soil we must be able to quantify how much pumice is in the mixture!

Specific Gravity of Pumice

- G_s is clearly size dependent when measured with a pycnometer due to gas in the internal voids not being fully replaced with fluid.
- Internal void structure can be destroyed by grinding down hand-selected pumice grains using mortar and pestle.
  - G_s of ground pumice material typically 2.3 - 2.35
  - In **unground** state, Gs of pumice even smaller than 2.35
  - Gs of hard-grained materials typically in range of 2.6 - 2.75

In a solution with Gs =2.35, pumice will float while "normal" hard-grained material will sink

Stringer (2019)

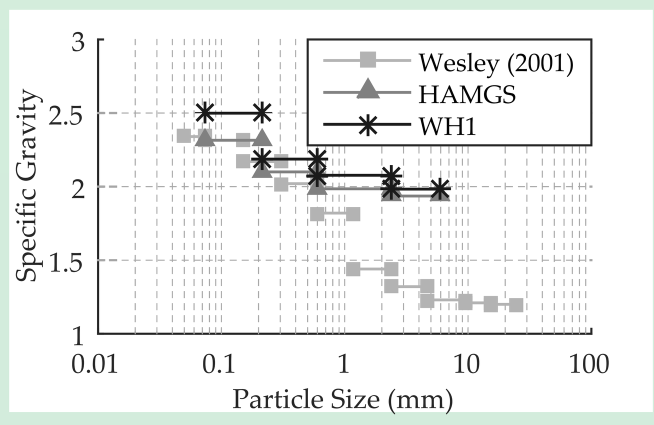

Figure 4: Specific gravity of pumice grains in near-pure pumice soil.

Separation by gravity

- Aqueous solutions of lithium heteropolytungstates (LST) are available to a specific gravity of **2.9**
  - Specific gravity adjusted by dilution or evaporation.
  - LST solutions have low toxicity. ⇒ appealing compared with the "heavy brines."
- Dry soil mixture is added to LST solution and thoroughly mixed. After initial separation, solution is mixed again and left to separate for at least 4 hours
- Separated components decanted, cleaned and weighed.

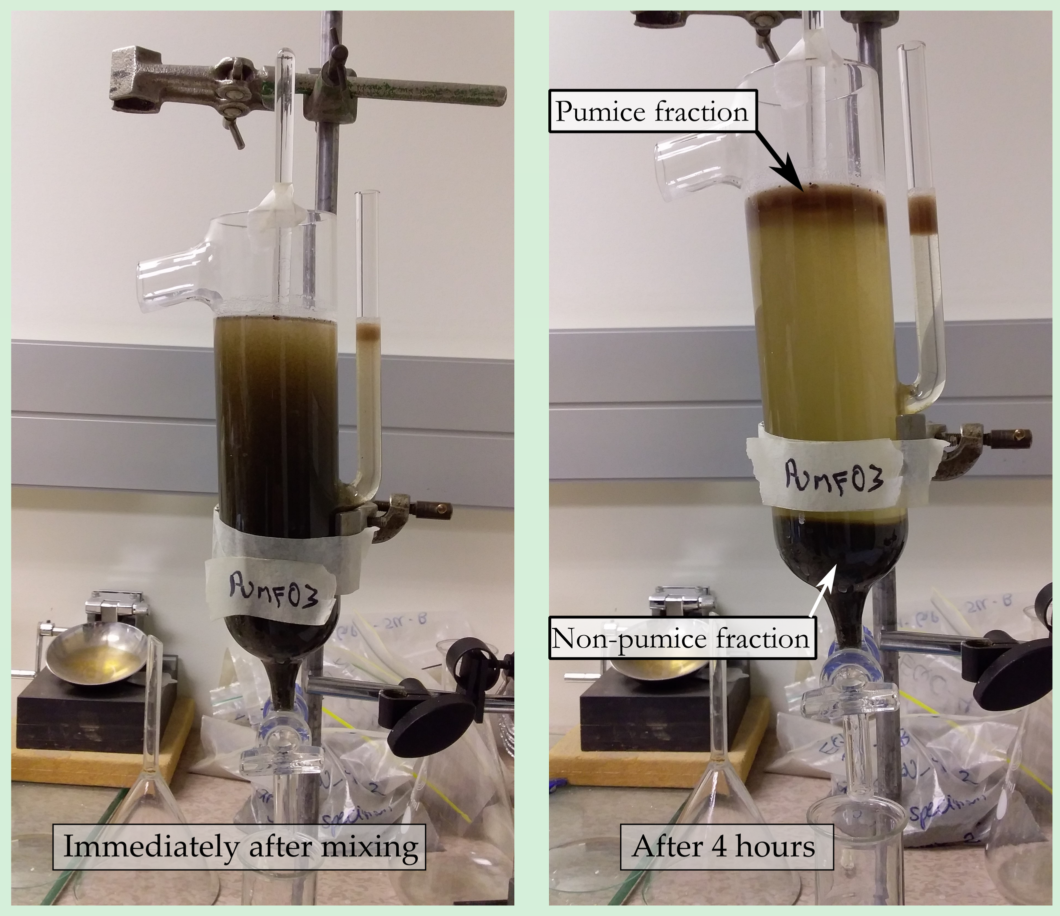

Figure 5: separation of pumice grains in a solution with Gs = 2..35

- LST solution is recovered by filtration & washing separated soil mixture with water
- Apparent accuracy of 3% by mass with mixtures of "milled pumice" and New Brighton Sand

Stringer (2019)

Application of Separation Technique

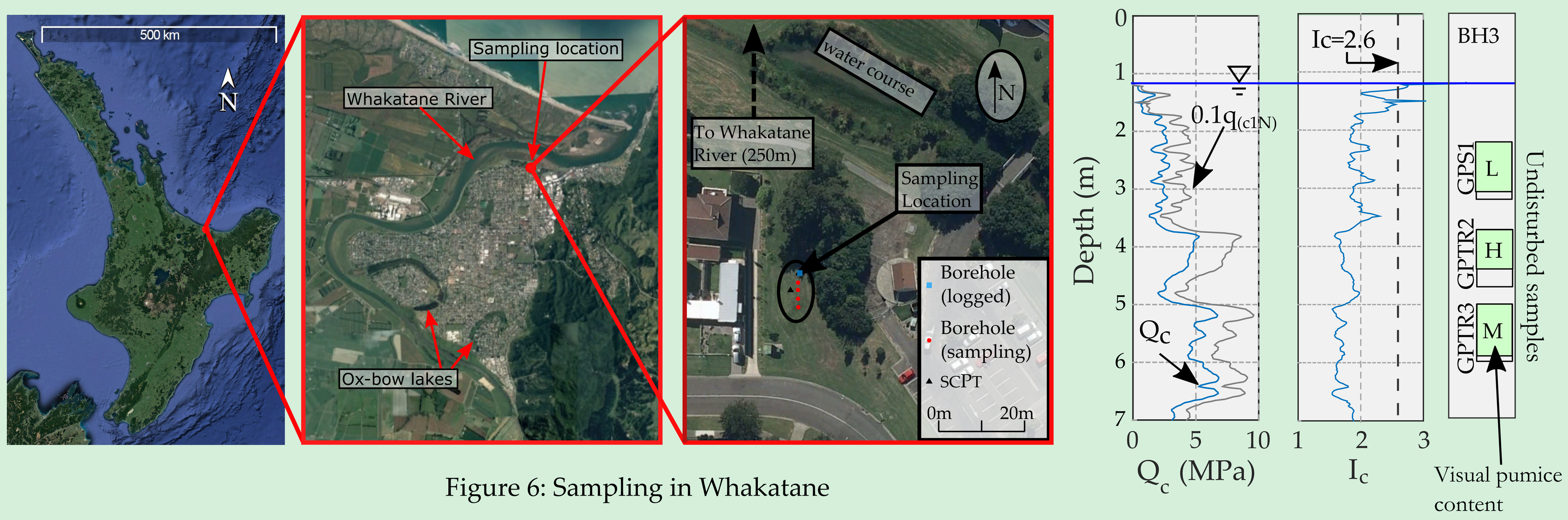

Figure 6: Sampling in Whakatane

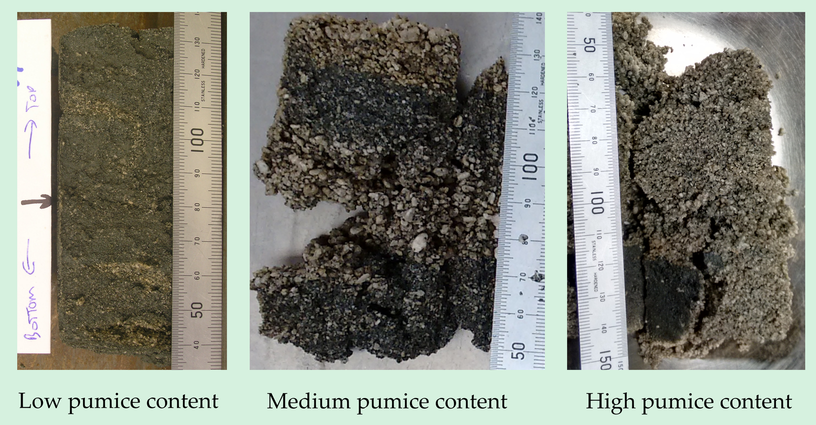

Figure 7: Interior of specimens with L,M,H pumice content

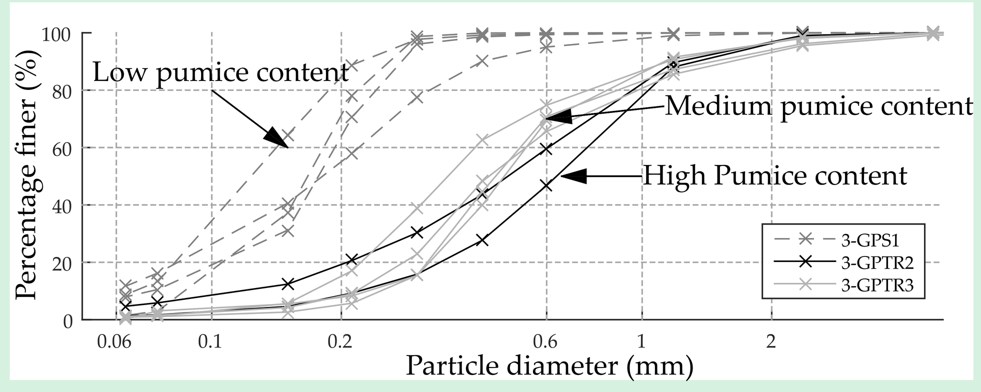

Figure 8: Conventional particle size distribution

- Undisturbed samples obtained for cyclic testing to determine CRR.
- Samples visually classified as high, medium and low pumice content
- Gravity separation showed these to have 70, 50 and 30% pumice content by mass

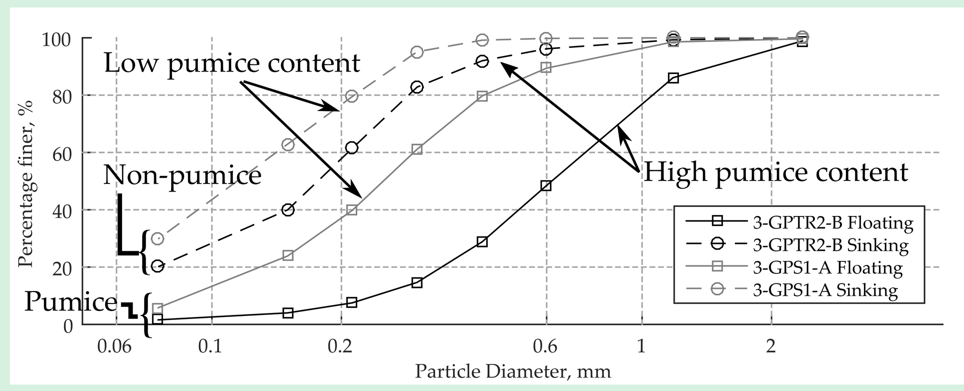

Figure 9: PSD of separated components of pumice-rich soil

- Clear differences in size distribution of the pumiceous material in the high/low pumice samples, yet hard grained fraction is similar.
- Obvious layering present in some samples - need to consider these effects on overall response

Stringer et al. (2019)

Summary

- Despite the variability of volcanic deposits, the pumice grains tend to have a specific gravity around 2.35 after destroying the internal void structure.
- The pumice grains can be separated from the hard-grained components in a soil mixture using LST solutions where the specific gravity is set to 2.35.
- Physically separating the pumice grains allows futher characterisation of both the pumice and the rest of the soil mixture. Relationships can be developed to account for differences in the behaviour of pumice-rich soils which are linked to pumice content
- The method can be extended to other problematic soils with very high or low specific gravity (i.e. mica).

References

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